AD-A158 718 STATIC STABILITY TEST OF THREE ELLIPTIC MISSILE BODY CONFIGURATIONS(U) ARNOLD ENGINEERING DEVELOPMENT CENTER ARNOLD AFS TN M E SELLERS MAY 85 AEDC-TSR-85-P8 1/1

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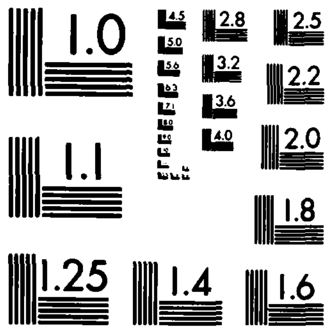

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NATIONAL BUREAU OF STANDARDS-1963-A

AEDC-TSR-85-P8

(2)

STATIC STABILITY TEST OF THREE ELLIPTIC MISSILE BODY CONFIGURATIONS

Marvin E. Sellers

Calspan Corporation/AEDC Division

AD-A158 718

May 1985

Final Report for Period April 18, 1985

ARNOLD ENGINEERING DEVELOPMENT CENTER
ARNOLD AIR FORCE STATION, TENNESSEE
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

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APPROVAL STATEMENT

This report has been reviewed and approved.

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Aeronautical Systems Branch
Directorate of Aersp Flt Dyn Test
Deputy for Operations

Approved for publication:

FOR THE COMMANDER

Elton R. Thompson

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Deputy for Operations

AD-A158 718

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SECURITY CLASSIFICATION OF THIS PAGE

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

A wind tunnel test was conducted to obtain data on the aerodynamic characteristics of three elliptic missile body configurations. The test was performed at nominal Mach numbers from 0.4 to 1.3 at a constant nominal free-stream unit Reynolds number of 2.4 million per ft. The angle-of-attack range was -4 to 20 deg at sideslip angles of 0 and 4 deg. Only sample tabulations of the test results are included in the report.

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11. TITLE

Static Stability Test of Three Elliptic Missile Body Configurations.

CONTENTS

APPENDIXES

NOMENCLATURE

A	Reference area, 0.18896 ft^2
AB	Base area, 0.18896 ft^2
AFA	Flow correction angle in pitch, deg
ALPHA	Angle of attack, deg
a	Semimajor (horizontal) span at X, in.
a_{max}	Semimajor span at model base, in. (See Table 1)
BETA	Sideslip angle, deg
b	Semiminor (vertical) height at X, in.
b_{max}	Semiminor height at model base, in. (See Table 1)
CA	Forebody axial-force coefficient, body axes, CAT-CAB
CAB	Base axial-force coefficient, body axes, -(PBA-P)AB/Q·A
CAT	Total axial-force coefficient, body axes, total axial force/Q·A
CDS	Forebody drag coefficient, stability axes
CLL	Rolling-moment coefficient, body axes, rolling moment/Q·A·L
CLM	Pitching-moment coefficient, body axes, pitching moment/Q·A·L
CLM-AO	Slope of CLM versus ALPHA curve at ALPHA = 0, deg^{-1}
CLN	Yawing-moment coefficient, body axes, yawing moment/Q·A·L
CLS	Forebody lift coefficient, stability axes
CN	Normal-force coefficient, body axes, normal force/Q·A
CN-AO	Slope of CN versus ALPHA curve at ALPHA = 0, deg^{-1}
CONFIG	Model configuration designation
CY	Side-force coefficient, body axes, side force/Q·A
L	Reference length, in. (See Table 1)
(L/D)S	Lift-to-drag ratio, stability axes

LM	Model length, 36.000 in.
M	Free-stream Mach number
NCP	Normal-force center-of-pressure location, body axes, inches from nose; XMRP-(CLM·L/CN) or XMRP-(CLM-AO·L/CN-AO) for ALPHA = 0
P	Free-stream static pressure, psfa
PBA	Average base pressure, (PBT + PBB + PBL + PBR)/4, psfa
PBi	Base pressure, i = T, B, L, and R, where T, B, L, and R are top, bottom, left, and right looking upstream, respectively, psfa
PHI	Roll angle, deg
PN	Data point number
PT	Tunnel-stilling chamber pressure, psfa
Q	Free-stream dynamic pressure, psf
RE	Free-stream unit Reynolds number, ft^{-1}
RUN	Data set identification number
T	Free-stream static temperature, °R
TT	Tunnel-stilling chamber temperature, °R
X	Axial location from nose of model, in.
XMRP	Axial distance from model nose to model moment-reference location, 24.000 in.
YCP	Side-force center-of-pressure location, body axes, inches from nose, XMRP-(CLN·L/CY)

1.0 INTRODUCTION

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), under Program Element 62201F, Control Number 2404, at the request of Air Force Wright Aeronautical Laboratories (AFWAL/FIMG), Wright-Patterson AFB, Ohio. The AFWAL/FIMG project manager was Mr. Don Shereda. The results were obtained by Calspan Corporation, AEDC Division, operating contractor for the aerospace flight dynamics testing facilities at the AEDC, AFSC, Arnold Air Force Station, Tennessee. The test was conducted in the Aerodynamic Wind Tunnel (4T) of the Propulsion Wind Tunnel (PWT) Facility on April 18, 1985, under AEDC Project Number CD48PB, PWT Test No. TC-793.

The purpose of the test was to obtain data on the aerodynamic characteristics of elliptic missile body configurations with ellipticity ratios of 2.0, 2.5, and 3.0 to 1.0. The test was performed at nominal Mach numbers from 0.4 to 1.3 at a constant nominal free-stream unit Reynolds number of 2.4 million per ft. The angle-of-attack range was -4 to 20 deg at sideslip angles of 0 and 4 deg.

The purpose of this report is to document the test and to describe the test parameters. The report provides information to permit use of the data but does not include any data analysis, which is beyond the scope of this report.

The final data package from the test has been transmitted to AFWAL/FIMG. Request for these data should be addressed to AFWAL/FIMG, Wright-Patterson AFB, OH 45433. A copy of the final tabulated data package is on file on microfilm at the AEDC.

2.0 APPARATUS

2.1 Test Facility

The AEDC Aerodynamic Wind Tunnel (4T) is a closed-loop continuous flow, variable-density tunnel in which the Mach number can be varied from 0.1 to 1.3 and can be set at discrete Mach numbers of 1.6 and 2.0 by placing nozzle inserts over the permanent sonic nozzle. At all Mach numbers, the stagnation pressure can be varied from 300 to 3,400 psfa. The test section is 4-ft square and 12.5 ft long with perforated, variable porosity (0.5- to 10- percent open) walls. It is completely enclosed in a plenum chamber from which air can be evacuated, allowing part of the tunnel airflow to be removed through the perforated walls of the test section. The model support system consists of a sector and sting attachment which has a pitch angle capability of -8 to 27 deg with respect to the tunnel centerline and a roll capability of ±180 deg about the sting centerline. A more complete description of the tunnel may be found in Ref. 1.

2.2 Test Articles

The installation of the test articles in Tunnel 4T is shown in Figure 1. The test articles were elliptic missile body configurations with ellipticity ratios of 2.0, 2.5, and 3.0 to 1.0. The models were power-law bodies with an exponent of 0.5 and had the same longitudinal distribution of cross-sectional area. The semi-major and semiminor axis ordinates were derived from the following equations:

For horizontal projection (semimajor axis)

$$a = \frac{a_{max}}{L^{0.5}} \cdot X^{0.5}$$

and for vertical projection (semiminor axis)

$$b = \frac{b_{max}}{L^{0.5}} \cdot X^{0.5}$$

Details of the models are given in Figure 2 and the model configuration designation is presented in Table 1.

2.3 Test Instrumentation

The aerodynamic forces and moments were measured using an internally-mounted, six-component strain-gage balance. Pressures were measured at the base of the model. The radial location of the pressure orifices are shown in Figure 3. The pressures were measured using 15 PSID pressure transducers which are part of the 4T standard pressure system.

3.0 TEST DESCRIPTION

3.1 Test Conditions and Procedures

Measurements of the model steady-state forces and moments were obtained at Mach numbers from 0.4 to 1.3. The nominal test conditions established during the test are given in Table 2. Tunnel conditions were held constant while varying model attitude. Data were recorded at selected angles using the pitch/roll-pause technique. Data were obtained at angles-of-attack from -4 to 20 deg at sideslip angles of 0 and 4 deg. A test run number summary is presented in Table 3.

3.2 Data Acquisition and Reduction

All steady-state measurements were sequentially recorded by the facility on-line computer system and reduced to the desired final form. The data were then tabulated in the Tunnel 4T control room, recorded on magnetic tape, and transmitted to the AEDC central computer file. The data stored in the central computer file were generally available for plotting and analysis on the PWT Interactive Graphics System within 30 seconds after data acquisition. The immediate availability of the tabulated data permitted continual on-line monitoring of the test results. A typical data plot generated on the PWT Interactive Graphics System is shown in Figure 4.

The model force and moment data were reduced to coefficient form in the body- and stability-axes systems. The model reference area is given in the Nomenclature and the reference lengths are given in Table 1. The moment reference point is shown in Figure 2. The stability-axis system coefficients (CLS and CDS) were calculated using the forebody axial-force coefficient (CA) and the normal force coefficient (CN). The base pressure and its area (given in Nomenclature) were used to calculate the base axial-force.

3.3 Corrections

The aircraft angles of attack and sideslip were corrected for sting deflections caused by aerodynamic loads. The flow angularity (AFA) in the tunnel pitch plane was determined by testing the aircraft model upright and inverted, and the flow angularity corrections were then applied to the data. Corrections for the components of model weight, normally termed static tares, were also accounted for before the measured loads were reduced to coefficient form.

3.4 Uncertainty of Measurements

Uncertainties (combinations of system and random errors) of the basic tunnel parameters, shown in Figure 5, were estimated from repeat calibrations of the instrumentation and from the repeatability and uniformity of the test section flow during tunnel calibration. Uncertainties in the instrumentation systems were estimated from repeat calibration of the systems against secondary standards whose uncertainties are traceable to the National Bureau of Standards calibration equipment. The tunnel parameter and instrument uncertainties, for a 95-percent confidence level, were combined using the Taylor series method of error propagation described in Ref. 2 to determine the uncertainties of the parameters in Table 4.

4.0 DATA PACKAGE PRESENTATION

The final data package contained, 1) tabulated data summaries listing specific parameters, 2) digital magnetic computer tapes containing summary data, 3) test article installation photographs, 4) test run number summary, 5) model configuration identification, and 6) model sketches. Sample tabulated data are presented in Appendix III.

5.0 REFERENCES

1. Test Facilities Handbook (Twelfth Edition). "Propulsion Wind Tunnel Facility, Vol. 4." Arnold Engineering Development Center, March 1984.

2. Abernethy, R.B. and Thompson, J. W., Jr. "Handbook - Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5 (AD755356), February 1973.

APPENDIX I

Illustrations

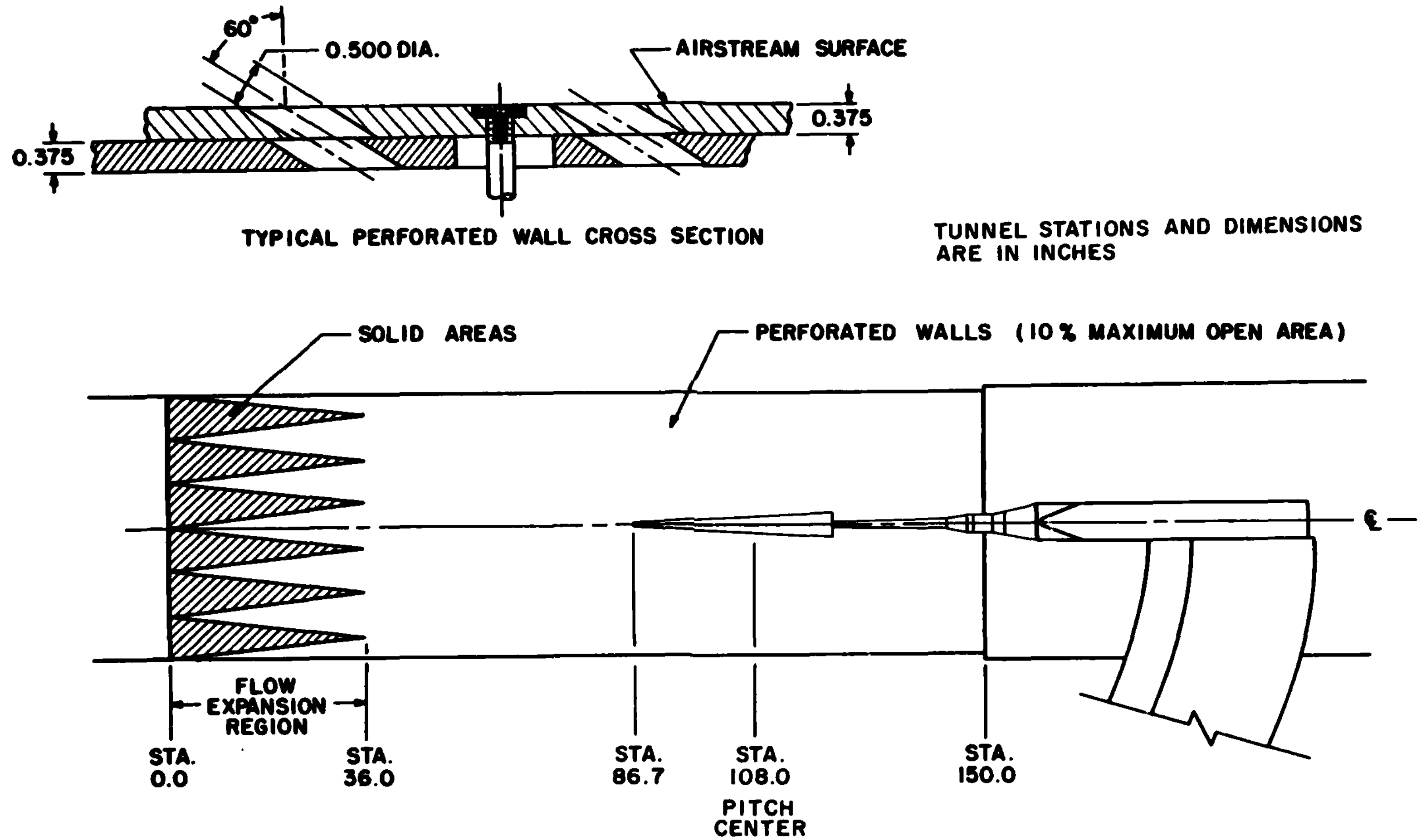
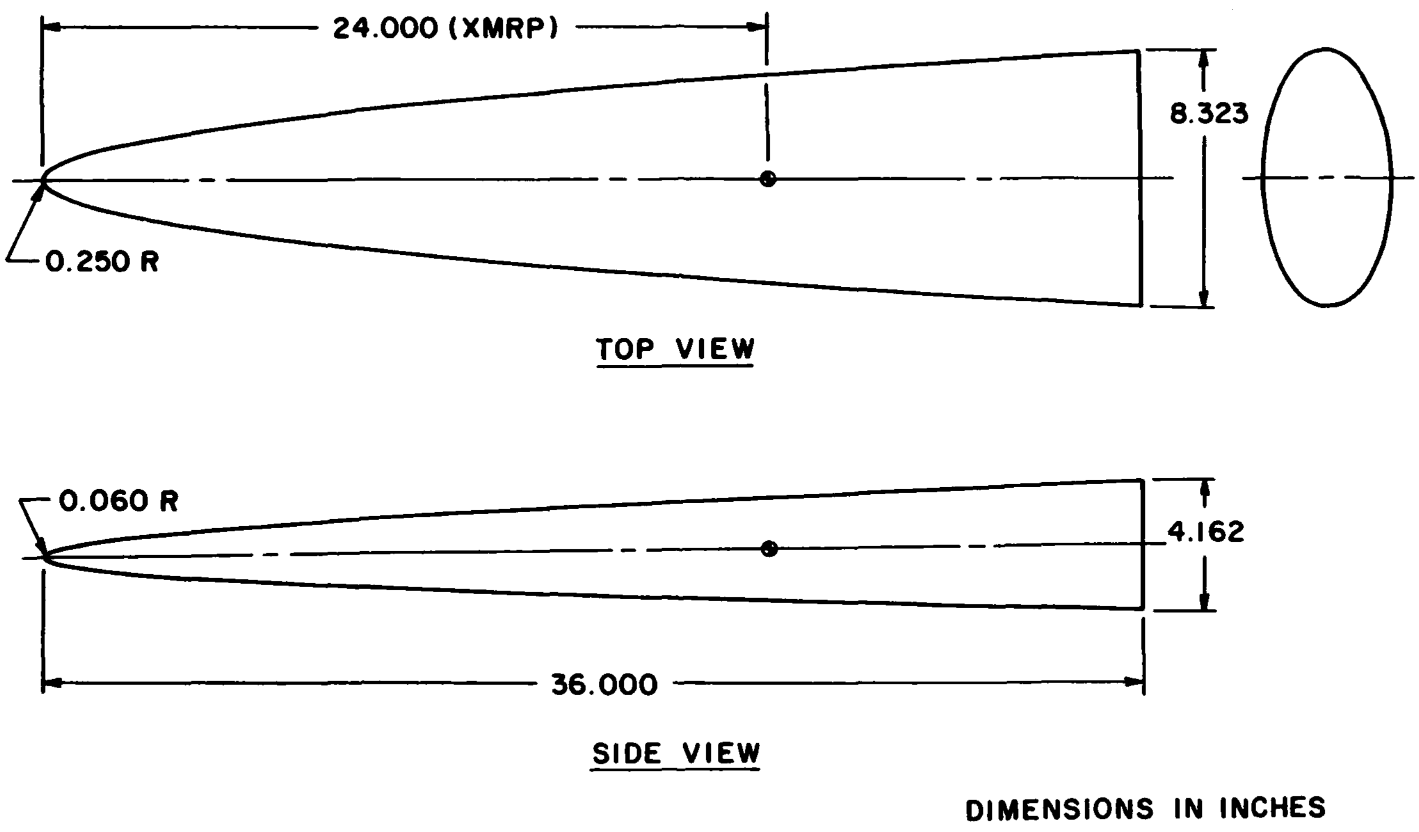


Figure 1. Model Installation

AFSC
Arnold AFS Tenn

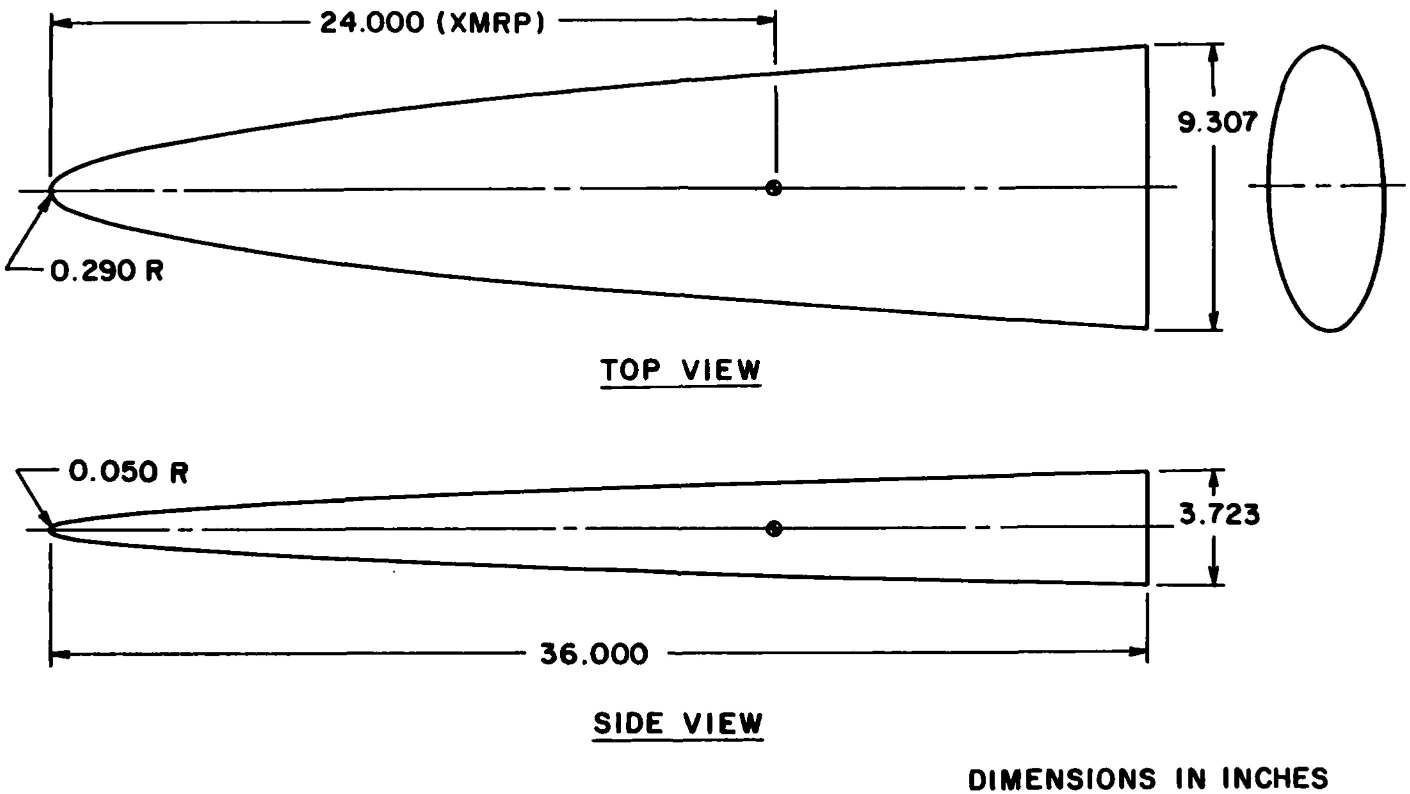
b. Configuration B20

Figure 1. Concluded



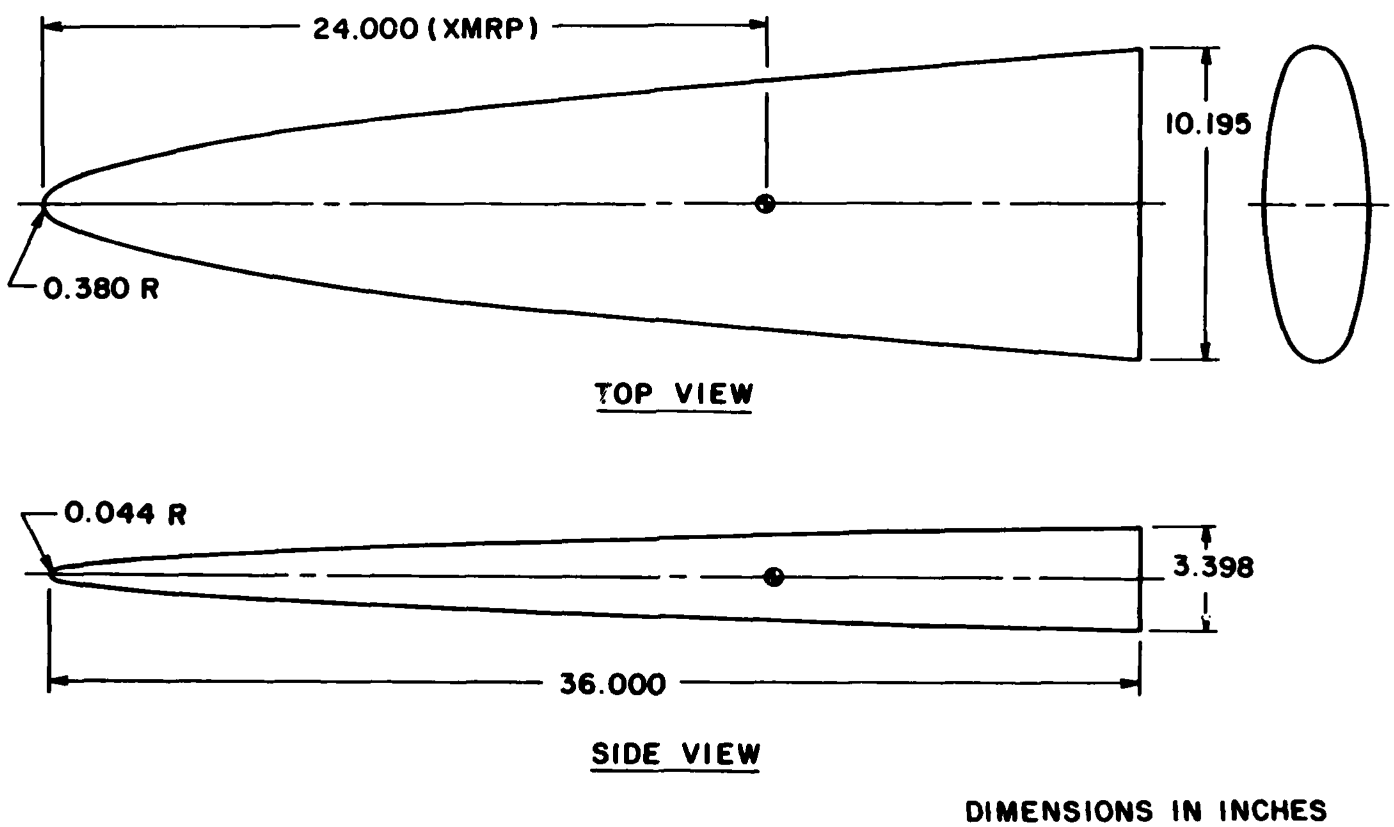
a. B20 Configuration

Figure 2. Model Details



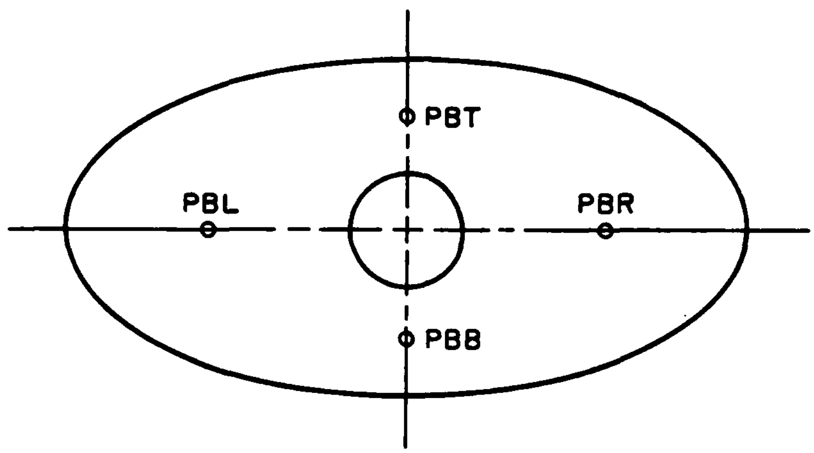
b. B25 Configuration

Figure 2. Continued



c. B30 Configuration

Figure 2. Concluded



Looking Upstream (PHI = 0)

Figure 3. Base Pressure Orifice Location

DATE 04-23-85 CALSPAN FIELD SERVICES INC.
PROJ- ARNOLD AFS,TN

**** TC789 ****
RUN = 47,82,106
MACH=0.4
1=B20 2=B25 3=B30

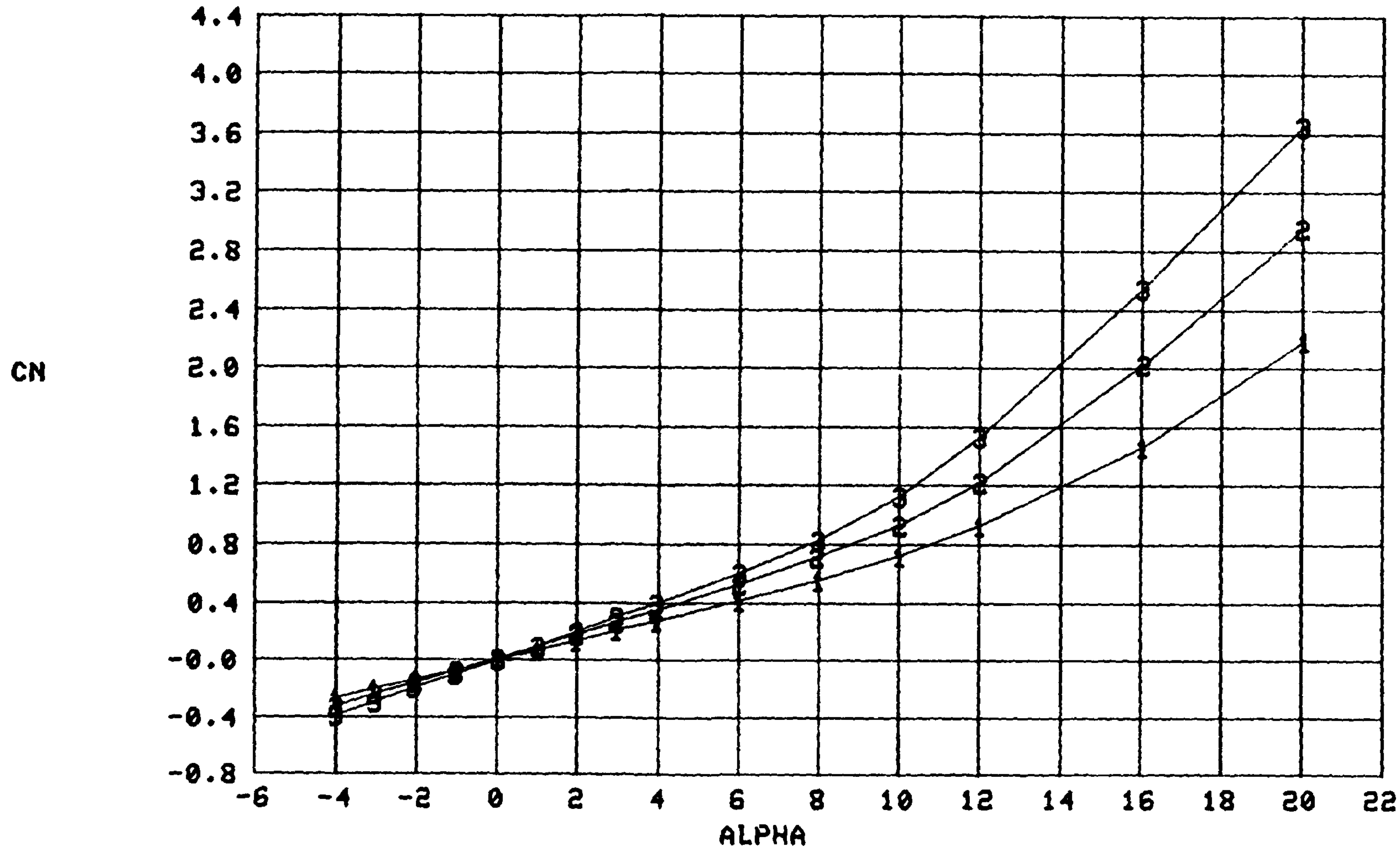


Figure 4. Typical Data Plot

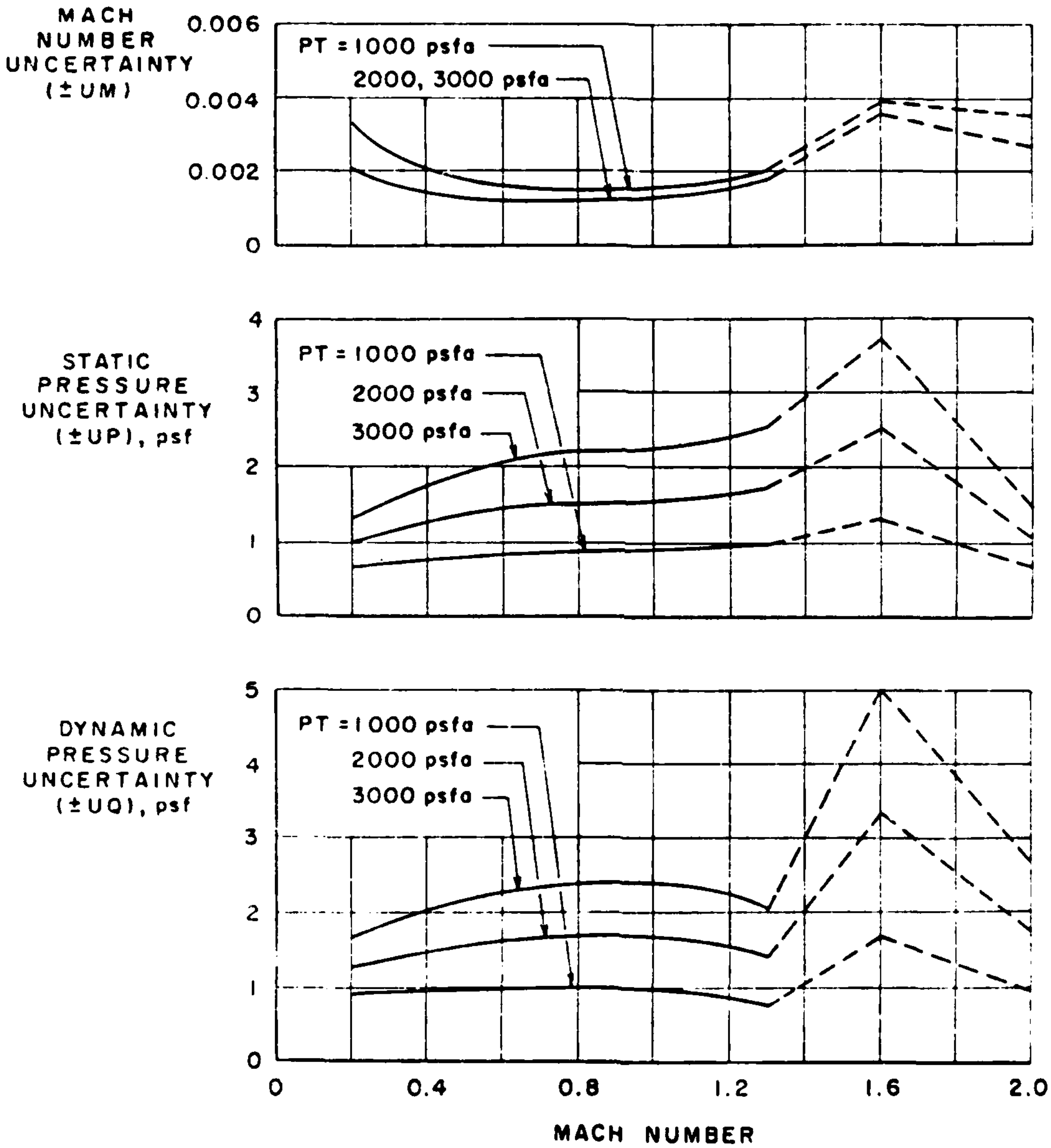


Figure 5. Estimated Uncertainties in 4T Tunnel Parameters

APPENDIX II

Tables

Table 1. Model Configuration Designation

CONFIG	Description
B20	2:1 elliptic body, a_{max} = 4.162 in.
	b_{max} = 2.081 in.
	L = 8.323 in.
B25	2.5:1 elliptic body, a_{max} = 4.654 in.
	b_{max} = 1.862 in.
	L = 9.307 in.
B30	3:1 elliptic body, a_{max} = 5.098 in.
	b_{max} = 1.699 in.
	L = 10.195 in.

Table 2. Nominal Test Conditions

M	PT	P	Q	RE x 10-6
0.4	2090	1872	210	2.37
0.55	1625	1324	281	2.40
0.8	1265	829	372	2.41
0.95	1174	659	414	2.39
1.05	1120	584	451	2.46
1.1	1120	524	444	2.36
1.2	1120	462	466	2.38
1.3	1120	405	479	2.37
1.3*	1170	424	500	2.47

* For CONFIG B30 only.

Table 3. Test Run Number Summary

CONFIG	ALPHA	BETA	M							
			0.4	0.55	0.8	0.95	1.05	1.1	1.2	1.3
B20	A1	0	47 72	50	54	57	60	63	66	70
		4	48	51	55	58	61	64	67	71
B25	A1	0	82	84	86	88	90	92	94	96
		4	83	85	87	89	91	93	95	97
B30	A1	0	106	108	111	113	115	118	120	122 123
		4	107	109	112	114	116	119	121	124

Notes: ALPHA Schedule: A1= -4,-3,-2,-1,0,1,2,3,4,6,8,10,12,16,20 deg

Table 4. Estimated Uncertainties

a. CONFIG B20

PARAMETER	M							
	0.4	0.55	0.8	0.95	1.05	1.1	1.2	1.3
CN	0.070	0.060	0.038	0.034	0.032	0.031	0.030	0.029
CLM	0.029	0.025	0.015	0.014	0.013	0.013	0.012	0.012
CY	0.039	0.034	0.022	0.020	0.019	0.019	0.018	0.017
CLN	0.032	0.028	0.018	0.016	0.015	0.015	0.014	0.014
CLL	0.020	0.017	0.011	0.0099	0.0096	0.0093	0.0089	0.0086
CAT	0.014	0.012	0.0076	0.0068	0.0065	0.0063	0.0060	0.0059
CA	0.016	0.014	0.0086	0.0076	0.0073	0.0070	0.0067	0.0066
CAB	0.0088	0.0080	0.0041	0.0035	0.0032	0.0032	0.0030	0.0030

b. CONFIG B25

PARAMETER	M							
	0.4	0.55	0.8	0.95	1.05	1.1	1.2	1.3
CN	0.073	0.063	0.039	0.035	0.033	0.032	0.030	0.029
CLM	0.028	0.023	0.015	0.013	0.012	0.012	0.011	0.011
CY	0.039	0.034	0.022	0.020	0.019	0.018	0.018	0.017
CLN	0.032	0.028	0.018	0.016	0.015	0.015	0.014	0.014
CLL	0.020	0.017	0.011	0.0099	0.0096	0.0093	0.0088	0.0086
CAT	0.014	0.012	0.0076	0.0068	0.0065	0.0063	0.0060	0.0059
CA	0.016	0.014	0.0086	0.0076	0.0073	0.0070	0.0067	0.0066
CAB	0.0088	0.0080	0.0041	0.0035	0.0032	0.0032	0.0030	0.0030

Table 4. Concluded

c. CONFIG B30

PARAMETER	M							
	0.4	0.55	0.8	0.95	1.05	1.1	1.2	1.3
CN	0.077	0.065	0.041	0.036	0.034	0.033	0.031	0.030
CLM	0.027	0.023	0.014	0.012	0.012	0.011	0.011	0.010
CY	0.039	0.034	0.022	0.020	0.019	0.018	0.018	0.017
CLN	0.032	0.028	0.018	0.016	0.015	0.015	0.014	0.014
CLL	0.020	0.017	0.011	0.0099	0.0096	0.0093	0.0088	0.0086
CAT	0.014	0.012	0.0076	0.0068	0.0065	0.0063	0.0060	0.0059
CA	0.016	0.014	0.0086	0.0076	0.0073	0.0070	0.0067	0.0066
CAB	0.0088	0.0080	0.0041	0.0035	0.0032	0.0032	0.0030	0.0030

APPENDIX III

Sample Tabulated Data

DATE. 5- 2-85 PROJECT NO. P41B-22
ARVIN/ SPAN FIELD SERVICES, INC.
AEDC DIVISION
PROPULSION WIND TUNNEL
ARNOLD AIR FORCE STATION, TENNESSEE

TEST TC-793 SUMMARY 1

RUN	M	PT	P	Q	REX10-6	TT	T	AFA	WIND/OFF	CONSET
50	0.550	1625.0	1322.8	280.4	2.399	557.7	525.8	-0.002	43/ 1	19

CONFIG	A	L	LM
B20	0.18896	8.323	36.000

AFWAL ELLIPTIC BODIES FORCE TEST

*** BODY AND STABILITY AXES DATA ***

PN	ALPHA	BETA	PHI	CN	CLM	CY	CLN	CLL	CAT	CAB	CA	NCP/LM	YCP/LM	CLS	CDS	(L/D)S
4	-4.00	0.01	-0.1	-0.271	-0.2028	0.004	-0.0016	-0.0003	0.2289	0.2199	0.0089	0.4939	0.7651	-0.270	0.028	-9.701
5	-3.03	0.01	-0.1	-0.202	-0.1537	0.004	-0.0013	-0.0003	0.2255	0.2151	0.0105	0.4909	0.7397	-0.201	0.021	-9.521
6	-2.04	0.00	-0.1	-0.133	-0.1039	0.003	-0.0017	-0.0003	0.2219	0.2117	0.0102	0.4860	0.8010	-0.133	0.015	-8.899
7	-1.02	0.00	-0.1	-0.063	-0.0526	0.002	-0.0018	-0.0003	0.2224	0.2090	0.0134	0.4742	0.8594	-0.063	0.015	-4.335
8	0.01	0.00	-0.1	0.004	-0.0022	0.003	-0.0009	-0.0001	0.2228	0.2050	0.0179	0.4953	0.7282	0.004	0.018	0.238
9	1.02	-0.00	-0.1	0.075	0.0492	0.004	-0.0002	0.0001	0.2225	0.2061	0.0164	0.5146	0.6767	0.074	0.018	4.198
10	1.99	-0.00	-0.1	0.142	0.0999	0.003	-0.0002	0.0001	0.2238	0.2076	0.0161	0.5046	0.6824	0.142	0.021	6.730
11	2.98	-0.01	-0.1	0.213	0.1494	0.003	0.0001	0.0002	0.2261	0.2079	0.0181	0.5045	0.6587	0.212	0.029	7.255
12	4.00	-0.01	-0.1	0.281	0.1981	0.004	0.0010	0.0002	0.2305	0.2212	0.0093	0.5035	0.6092	0.279	0.029	9.663
13	6.05	-0.01	-0.1	0.420	0.2991	0.004	0.0003	0.0005	0.2407	0.2400	0.0007	0.5022	0.6494	0.418	0.045	9.297
14	7.99	-0.01	-0.1	0.569	0.3979	0.003	0.0015	0.0004	0.2510	0.2652	-0.0142	0.5051	0.5621	0.566	0.065	8.699
15	10.03	-0.02	-0.1	0.746	0.5003	0.001	0.0011	0.0006	0.2523	0.2956	-0.0432	0.5116	0.3293	0.742	0.087	8.494
16	12.02	-0.02	-0.1	0.959	0.6003	-0.001	0.0016	0.0011	0.2422	0.3091	-0.0669	0.5219	1.3169	0.952	0.134	7.097
17	16.07	-0.03	-0.1	1.529	0.8380	-0.004	0.0037	0.0017	0.2097	0.3294	-0.1197	0.5399	0.8753	1.502	0.308	4.874
18	20.03	-0.03	-0.1	2.244	1.1789	-0.003	0.0037	0.0035	0.1707	0.3441	-0.1735	0.5452	0.9349	2.167	0.606	3.578

CN-AO	CLM-AO
0.0682	0.0504

Sample 1. Body- and Stability-Axes Data

DATE. "- 2-85 PROJECT NO. P41B-22
ARVIN/ SPAN FIELD SERVICES, INC.
AEDC DIVISION
PROPULSION WIND TUNNEL
ARNOLD AIR FORCE STATION, TENNESSEE

TEST TC-793 SUMMARY 2

RUN	M	PT	P	Q	REX10-6	TT	T	AFA	WIND/OFF	CONSET
50	0.550	1625.0	1322.8	280.4	2.399	557.7	525.8	-0.002	43/ 1	19

CONFIG	A	L	LM
B20	0.18896	8.323	36.000

AFWAL ELLIPTIC BODIES FORCE TEST

PN	ALPHA	BETA	PHI	PBT/P	PBR/P	PBB/P	PBL/P	PBA/P
4	-4.00	0.01	-0.1	0.9597	0.9476	0.9588	0.9476	0.9534
5	-3.03	0.01	-0.1	0.9610	0.9485	0.9598	0.9480	0.9543
6	-2.04	0.00	-0.1	0.9623	0.9492	0.9605	0.9487	0.9552
7	-1.02	0.00	-0.1	0.9628	0.9496	0.9613	0.9489	0.9557
8	0.01	0.00	-0.1	0.9634	0.9509	0.9624	0.9500	0.9567
9	1.02	-0.00	-0.1	0.9628	0.9511	0.9627	0.9494	0.9565
10	1.99	-0.00	-0.1	0.9616	0.9509	0.9623	0.9491	0.9560
11	2.98	-0.01	-0.1	0.9613	0.9509	0.9621	0.9491	0.9559
12	4.00	-0.01	-0.1	0.9586	0.9486	0.9592	0.9466	0.9532
13	6.05	-0.01	-0.1	0.9538	0.9451	0.9546	0.9433	0.9492
14	7.99	-0.01	-0.1	0.9501	0.9380	0.9508	0.9354	0.9436
15	10.03	-0.02	-0.1	0.9465	0.9300	0.9474	0.9256	0.9374
16	12.02	-0.02	-0.1	0.9449	0.9264	0.9452	0.9218	0.9346
17	16.07	-0.03	-0.1	0.9422	0.9213	0.9376	0.9195	0.9301
18	20.03	-0.03	-0.1	0.9398	0.9182	0.9348	0.9159	0.9272

Sample 2. Base Pressure Data

END

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DTIC